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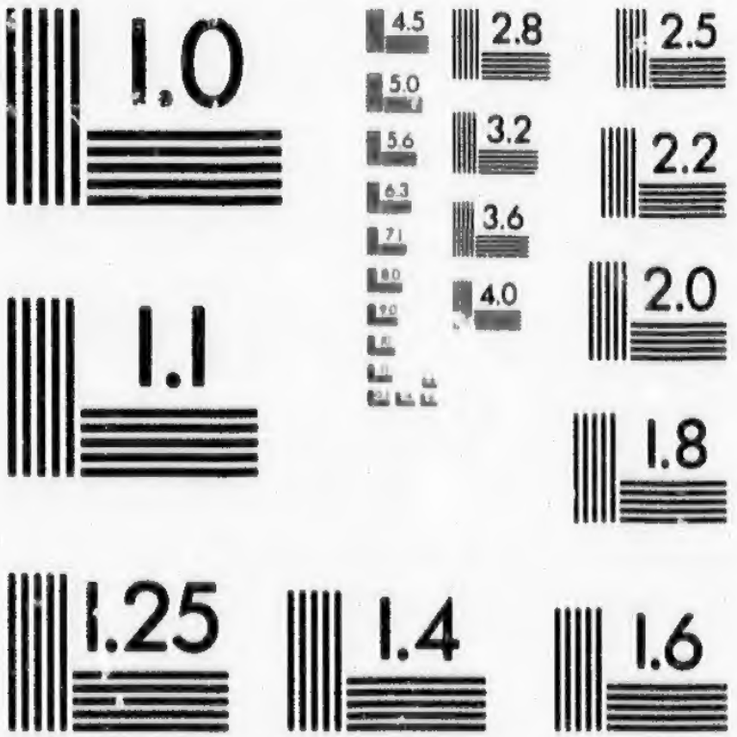

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DR. R. MAURICE BUCKE of London, Ont.

ON THE FUNCTIONS OF THE GREAT SYMPATHETIC NERVOUS SYSTEM.

MR. PRESIDENT AND GENTLEMEN,—I propose for submit to your consideration to-day some thoughts upon the functions of the great sympathetic nervous system which have occupied my mind in a more or less coherent form for many years, and if it shall seem, as it may, upon first sight, to some of you, that certain of the views which I have to propound are extravagant, I trust that you will not condemn them hastily, but as men belonging to, and worthy of, a liberal profession, that you will calmly weigh and, without passion or prejudice, adopt or reject them as shall seem to your judgment best.

Although it is necessary that you should have a tolerably clear idea of the structure and distribution of the great sympathetic in order to follow me in the remarks which I propose to make, yet I do not intend to do more than to recall briefly to your minds the general outlines of this part of the subject, with which you are all of necessity more or less familiar. You will recollect that the great sympathetic consists in the first place of a double chain of ganglia over fifty in number extending from the base of the brain along the sides of the spinal column to the coccyx; in the second place of certain ganglia such as the superficial and deep cardiac, the semilunar, and innumerable others named and unnamed, scattered among the thoracic, abdominal, and pelvic viscera; and thirdly of innumerable nerve cords, these last being capable of division into three classes; namely: (1) those which connect the sympathetic ganglia to one another, these are not strictly speaking nerve cords, but are prolongations of the ganglia in a cordlike form; (2) next those which connect the sympathetic with the cerebro-spinal nervous system; and (3) lastly those which arising in the sympathetic ganglia are distributed to the various organs which are supplied with nerves from this nervous system. The only other thing to be especially remarked about the structure of this great nerve is the immense number and great complexity of its plexuses. These plexuses, speaking generally, are made up of nerve cords from different sympathetic ganglia, of filaments derived from spinal nerves, and others from cranial nerves; that is, in a given plexus there will unite nerves from perhaps two, three, or more sympathetic ganglia, with filaments from one or more spinal nerves, and perhaps from one or two cranial nerves; from these plexuses the nerves proceed to their ultimate distribution, the object of the plexus seeming to be to bring together and combine these various elements in order to form an extremely complex nerve. Now as regards the ultimate distribution of the great sympathetic, a matter of great importance to us in deciding upon its functions; in the first place it sends branches to all the spinal and cranial nerves, which presumably follow the course of those nerves and are distributed with them to the organs supplied with nerves by the cerebro-spinal nervous system. Secondly it is probably distributed to the coats of all the arteries in the body, though the arteries carrying blood to the head, face, and glandular organs are better supplied by it than others; thus the common, internal, and external carotids, the phrenic, the renal, the gastric, hepatic, splenic, superior mesenteric, sacral, internal iliac, vesical and uterine arteries, are known to be freely supplied by it. Thirdly the viscera, thoracic, abdominal, and pelvic, are all supplied more or less abundantly with sympathetic nerves. I will mention the different organs in their order, according to the amount of the supply, relative to their mass, which they severally receive, as well as I have been able to ascertain it, but I must warn you that this classification is only approximative; between two such organs, for instance, as the spleen and pancreas it is impossible to say which is best supplied. You will see as we go on that this classification, although imperfect, is somewhat important in view of the deductions that we shall be able to draw from it. (1) At the head of the list beyond all question stands the heart, for it not only receives the six cardiac nerves from the upper, middle,

and inferior cervical ganglia, and has four plexuses, the two cardiac and two coronary, entirely devoted to its supply, but it has also numerous ganglia imbedded in its substance which are centres of nerve force for its own use over and above. (2) Next to the heart probably comes the radiating fibres of the iris. (3) Then the supra-renal capsules. (4) In the fourth rank stand I think the sexual organs, both male and female, and especially the testes and ovaries. (5) The organs of special sense, the eye, the internal ear, the nasal mucous membrane, and the palate. (6) After these organs must be placed the stomach, the whole intestinal tract, and the liver. (7) Then the thyroid gland, kidneys, spleen and pancreas. (8) Last of all come the lungs which receive in proportion to their size a remarkably small supply.

There is just one thing more to say about the anatomy of our subject before proceeding to its physiology, and that is to give you a list of organs supplied by the sympathetic and not by the cerebro-spinal nervous system; and it is as well that you should bear in mind that this division of parts is not absolute but relative, for as the sympathetic, in all its extent probably, has cerebro-spinal fibres mixed with it, so all parts which are supplied with nerves by it no doubt do receive some filiments from the cerebro-spinal system, but these fibres are small and few and are also probably modified in their functions by being so intimately connected as they are with sympathetic nerves; the division of organs therefore into those supplied by both systems, and those supplied by the sympathetic alone, though not an absolute division is still a real one; in this list we have then the radiating fibres of the iris, the arterial coats, the liver, the kidneys, the supra-renal capsules, the ovaries, the pancreas, and the intestinal tract, including both muscular coat and glands; and to this list I believe I may fairly add the body of the bladder and of the uterus.

Now as to the functions of the great sympathetic. Some physiologists, as Todd and Bowman, seem to consider that the sympathetic differs very little in its functions from the cerebro-spinal system, and that, at least in some points, its function is identical with the latter nervous system. There are some general considerations which make this view appear to me unlikely to be correct. (1) In the first place, though both nervous systems are made up of nerve cells and nerve fibres, yet both the cells and the fibres of the great sympathetic nervous system differ materially in structure from the cells and fibres of the cerebro-spinal nervous system, and it can scarcely be supposed that such different structures should not manifest some corresponding difference in their functions. (2) Secondly, the great sympathetic system, in the arrangement of its parts, in the great number and extraordinary diffusion of its ganglia, and in the immense number and complexity of its plexuses is too unlike the cerebro-spinal nervous system for us to suppose that their functions can be anything like identical. (3) Thirdly, the great sympathetic is distributed mainly to organs in the interior of the body that do not require, and are not endowed with sensibility, at all events to anything like the same degree as obtains in the case of the external organs which are supplied with nerves by the cerebro-spinal nervous system. (4) And lastly, if the great sympathetic has the power of exciting contractily in muscles at all, we shall see that this power is materially different from that possessed by the motor centres of the cerebro-spinal system.

What, then, are the functions of the Sympathetic Nervous System? I shall consider this subject by seeking to give rational answers, deduced from acknowledged facts, to the following five questions. (1) First, is it a motor nervous system, and if so, in what sense? (2) Second, is it endowed with sensation? (3) Third, does it control the functions of the secreting glands, as the gastric, intestinal, salivary, and lachrymal, the liver, kidneys, and pancreas? (4) Fourth, does it influence the general nutrition of the body, and if so in what manner? (5) Fifth, is it the nervous centre of the moral emotions?

Let us discuss these questions in their order.

(1) The first question is: Is the sympathetic a nerve of

motion? The only muscular structures which receive nerves from the sympathetic and none from the cerebro-spinal system are the muscular coats of the arteries, the radiating fibres of the iris, and the muscular coat of the intestines. It would be almost though not absolutely correct to include in this list the bladder and the uterus. Any nervous stimulation received by these must therefore be sent from the great sympathetic, and that these structures are influenced by some nervous system is certain, as we shall see farther on. We may therefore say positively that the great sympathetic does act as a nerve of motion. You will notice, however, that all these structures are made up of unstriped muscular fibre; I infer from this that the great sympathetic is a nerve of motion to unstriped muscle. In the case of the heart whose muscular fibres are striped, though they are not precisely similar to ordinary striped muscles which are supplied by the cerebro-spinal system and are under the control of the will, there seems to me no room to doubt that its movements are influenced by the great sympathetic, and this we must take as a partial exception to what I believe to be the law, namely: that the movements of striped muscle are controlled by the cerebro-spinal nervous system, and the movements of unstriped muscle by the great sympathetic. The only other exception to this law that I am aware of is the case of the circular fibres of the iris which being unstriped muscle are supplied by the third cranial nerve.

(2) If we apply the same reasoning to the solution of the question—Is the great sympathetic a sensory nerve?—we do not get a very clear answer; parts supplied only by the great sympathetic as the liver, kidneys, pancreas, supra-renal-capsules, and ovaries, are probably scarcely if at all sensitive. Arguments as to the sensitiveness of these organs drawn from their pathological conditions I do not think of much value, for such pathological states usually involve the investing membrane of these organs, either by congestion of it, stretching of it, or in some other way, and we know that this investing membrane, the peritoneum, is supplied by cerebro-spinal nerves and is very sensitive. On the other hand pathological conditions of these organs which do not interfere with their investing membrane, as cancer of the liver in cases where all the cancerous nodules are buried in the substance of the organ and do not encroach upon the peritoneum and many diseases both of the liver and kidneys leading to fatal disintegration of tissue are quite painless. The organs which I have mentioned as being supplied solely by great sympathetic nerves are by their position well protected both by being surrounded by sensitive tissues and organs, and by being invested by a highly sensitive membrane, they do not therefore require for their protection that they themselves should be sensitive, and I do not believe that they are so. Another fact which bears out this view remains to be mentioned. When organs analagous to those of which we have been speaking—other glands, as the mammary, salivary, testes, &c.—are placed in exposed situations they are then supplied with cerebro-spinal nerves as well as with those from the sympathetic—the sympathetic fibres being undoubtedly intended to control their functions, and the cerebro-spinal fibres to make them sensitive and so protect them from injury. For if, on the one hand, the great sympathetic fibres were endowed with sensibility there would be no occasion for a supply of cerebro-spinal nerves to these organs; or if, on the other hand, the cerebro-spinal nerves are not sent to them to furnish them with sensibility but to control (as some physiologists maintain) their secreting functions, then there would be no apparent reason why they should be supplied by great sympathetic nerves. All things considered therefore I am inclined to answer this question in the negative. I do not believe that the great sympathetic is endowed with sensation.

(3) The third question is: Does the great sympathetic exercise a controlling influence over the functions of the secreting glands? I think there need be no hesitation about answering this question in the affirmative. The ordinary function of these glands might be supposed to be carried on independently of nervous influence altogether, though I do not think it all likely that it is, for as

in the healthy condition of the body the secreting process of every gland is carried on with reference to other parts besides itself, so there seems no means by which the function of a given gland could be so co-ordinated to the condition of other parts of the economy except through the agency of a nervous system distributed to each, and through which a chain of intelligence (if we may use that word) can be maintained. If any nervous system performs the office here indicated it must of necessity be the great sympathetic, for the following reasons: (1) The will has no influence upon the functions of the secreting glands; (2) in cases of general paralysis from disease or injury of the cord the function of the secreting glands is performed almost if not quite as well as when the cerebro-spinal system is intact; (3) the great sympathetic is the only nervous system which is distributed to all the glands, the liver and kidneys receiving nerves from no other. As for the cases of the extraordinary action or want of action of these glands in some emotional states, as for example, the excessive secretion of urine in fear, of tears in grief, of saliva in hunger; and conversely, the arrest of the buccal and salivary secretions in terror, the arrest of the gastric secretions from almost any marked emotional excitement, the well known increase, arrest, and alteration of the mammary secretion from the influence of terror, maternal love, and rage; these cannot be explained without referring them to the influence of some nervous system over the glands in question. I think, for the following reasons, that this nervous system is the sympathetic: (1) In the first place some of these glands, as the kidneys, receive no other than sympathetic nerves; (2) and in the second place the great sympathetic sends a liberal supply of nerves to all of them. It does not send nerves to those glands which are not supplied by the cerebro-spinal system, and very few or none to such glands as are supplied by it. On the contrary, if you will recall an attempted classification in a previous page of this essay you will see that there the kidneys which receive no nerves but from the great sympathetic rank in the seventh order of organs according to the quantity of sympathetic nerves which they receive—the testes, ovaries, the gastric and intestinal glands all come before the kidneys as all receiving more sympathetic nerves than do these—of these organs the ovaries, supra-renal capsules, and liver receive no cerebro-spinal nerves, but the other organs all do, and some of them, as the testes and gastric glands, receive a tolerably large supply of nerves from this system. If then, some secreting organs are certainly influenced by emotional states through the medium of the sympathetic, and if the great sympathetic is supplied just as copiously, or more so to other organs whose functions are also influenced by emotional states, is it not reasonable to conclude that the medium is the same in all cases, and that it is through the great sympathetic that emotional conditions affect the secretions? But this is not all. We have seen above that it is a strict rule that secreting glands are supplied with cerebro-spinal nerves copiously or the reverse according to the degree of their exposure to injury from without, thus the salivary and mammary glands are well supplied, while the kidneys and liver receive no cerebro-spinal fibres at all. So, too, the testes are supplied with cerebro-spinal nerves, while the homologous organs in the female—the ovaries—are not. So that on the one hand without supposing that the cerebro-spinal nerves going to these organs have anything to do with their functions, we can understand why they are sent there. And on the other hand we have shown that they are not needed to explain the functional phenomena of these organs, for these are the same in glands which are and in those which are not supplied with cerebro-spinal fibres. But there is still another word to say in support of this view, and it is this. Cerebro-spinal nerves are either nerves of sensation or nerves of motion. Now in the case, for instance, of the mammary gland which is supplied with cerebro-spinal nerves derived from the anterior and lateral cutaneous nerves of the thorax, those branches which are distributed to the mammary glands are either sensory or motor nerves. Now if we suppose that these nerves control the secreting functions of the gland we must either suppose that a motor nerve is

able to take on this function which does not seem likely, or we must suppose that it is accomplished by a sensory nerve, and in that case we must suppose that the nerves in question are capable of carrying the current which has this influence on the gland the reverse way to its ordinary use,—for the current in a sensory nerve flows from the periphery to the centre, but this current of nervous influence of which there is now question, flows along the nerve from the centre to the periphery. If you will carefully weigh these considerations I think you will have no difficulty in agreeing to the following propositions. (1) That the great sympathetic can and does exercise a controlling influence over the secretion of some glands, as the kidneys, which receive no other nerves. (2) That as it is at least equally distributed to other glands which receive cerebro-spinal nerves, and no other function appears for it to perform, it influences their secreting functions also. (3) That cerebro-spinal nerves when sent to glands have another obvious function to perform besides that of controlling the secretions of these glands, and that it is consequently unnecessary to suppose that they do this likewise. (4) And finally, it does not seem likely, for the reasons adduced, that the nerves derived from the cerebro-spinal system can or do influence the functions of secreting organs.

(4) The fourth question is, does the great sympathetic influence the general nutrition of the body; and if so in what manner? The nervous power which controls nutrition must be universal since nutrition itself is universal—the great sympathetic nerve is distributed to the whole system, while many parts are not supplied by the cerebro-spinal system. For all cranial and spinal nerves receive branches from the sympathetic which are presumably distributed with the spinal and cranial nerves. Also all arteries are accompanied by sympathetic nerves which are distributed to the parts to which the arteries go, so that in fact the distribution of the great sympathetic nerve is probably absolutely universal while the distribution of the cerebro-spinal is far from being so. The nutrition of paralyzed limbs though not up to par on account of want of exercise is still pretty well kept up, while if those limbs could be deprived of sympathetic nervous influence instead of cerebro-spinal nervous influence we have reason to believe that their nutrition would fail absolutely and that they would die. If the sympathetic be divided upon one side of the neck the immediate effects of the operation are as follows: The corresponding side of the head and face is immediately very much congested and the temperature of the same parts rises several degrees (8° to 9°). The meaning of these changes would seem to be that the muscular coats of the arteries are paralyzed by division of the nerve which supplies them, and that oxydation of the tissues takes place too rapidly. Whether oxydation of the tissues is hastened in consequence of the congestion which is due to the paralysis of the muscular coats of the arteries, or whether it is due to a direct loss of nervous energy supplied by the sympathetic to the tissues themselves, and by virtue of which retrograde metamorphosis is, in the normal state of the parts, held in check, I do not think can in the present state of our knowledge be determined. It is, in any case, undoubtedly true that either directly or indirectly the great sympathetic exercises a controlling influence over that process of cell growth and destruction which we call nutrition. To what extent the process of nutrition is dependent upon a supply of nerve force derived from the sympathetic is a more difficult matter to decide. We know that this process goes on in plants, and in animuls too low in the scale to have a sympathetic system [though one high authority believes that all animals have a sympathetic system, and that even plants have an analogous organ], and judging from this fact the process of nutrition is probably not entirely dependent upon nervous influence. But it would seem that while going on under the general laws of chemical selection, and of cell growth and destruction, which are common to all organized beings, the highest as well as the lowest, to plants as well as to animals, it is still subject to what we may call a general supervision of the great sympathetic system.

(5) The last question which we have to answer in regard to the functions of the great sympathetic is: Is it the nervous centre of the moral nature? I believe it is. And first it will be necessary to define the meaning here attached to the expression "moral nature." You will understand, of course, that I mean by it something quite distinct from the intellect which along with it makes up the whole psycological nature of man. Now we all know that the manifestations of these two, the intellectual and moral natures, constantly occur together. That is to say, the idea of a thing or person being called up by the mind a feeling of pity, tenderness, love, fear, hate, annoyance, or a feeling of some kind arises at or about the same time towards the same thing or person; and to all appearance the idea and feeling arise together and are simply two aspects of one mental state. Now, what I want to impress upon you is that this is not the correct view to take of the matter at all; but that either the idea at first arises and then the feeling which may be said to color it; or that the feeling having arisen primarily it either suggests the idea by association and then colors it, or the idea being suggested by something else besides the feeling it is all the same colored by it to a greater or less degree. The intellectual nature includes every kind and degree of thought, from the simple presentation of the image of a natural thing to the mind, to the most abstruse reasoning,—it includes among its divisions perception, conception, memory, imagination, reasoning, comparison, abstraction and judgment. The moral nature, on the other hand, includes every form of passion and emotion and some feelings that are not classed as either passions or emotions, such as faith, trust, confidence; as an incomplete catalogue of the divisions of the moral nature, including some compound states partly ideational partly emotional. I may mention, and I purposely place the antithetic emotions in juxtaposition—love, hate; courage, or faith, fear; trust, suspicion; joy, grief; high spirits, low spirits; exultation, dejection; triumph, despair; tenderness, surliness; patience, impatience; confidence, shame. Now it must be borne in mind that these moral states have all of them a wide range in degree; that for instance there is no difference in kind between a casual liking and the most intense love; between a slight feeling of dislike and the bitterest hate; between the faith that makes us take the word of an acquaintance for a few dollars, and the faith which enables the martyr to walk exultingly to the stake; between the feeling of uneasiness that something may be going wrong, and the agony of extreme terror; and so through them all. Now the intellectual and moral natures being, for the sake of the argument, defined as above, I contend that they are functions of two different organs, or of two different parts of the same organ, for the following reasons: (1) A continuous current of ideational states and a continuous current of emotional states constantly exist and flow on together without interfering with one another except through the association of certain ideas with certain emotional states. (2) Any idea may exist associated with almost any emotional state. (3) There is no fixedness between ideas and emotional states such as there would be if they were the concurrent functions of one organ. (4) Any idea may exist without the coexistence of any emotional state. (5) Any simple emotional state, as fear, anger, or love, may exist without being associated with any idea. The intellectual and the moral natures being for these reasons presumably functions of different parts of the nervous system, or of different nervous systems, let us see if it be possible to determine what part of the nervous system the moral nature is a function of.

In considering this part of our subject we have to look at the problem from two sides the converse of each other, namely: (A) First, we have to consider the different ways by which emotions are caused or excited, and see whether their causes are such as act upon the cerebro-spinal nervous system, or upon the great sympathetic. Then (B) secondly, an emotion being excited we have to consider the effect of this emotion on the economy and see whether those organs supplied by the sympathetic are primarily affected and most affected by the nervous excitement which is the physical accompaniment of the emotion, or wheth-

er those organs supplied by the cerebro-spinal nervous system are those which are first and most affected.

(A) We have then to consider in the first place emotional excitants and to try to determine from their seat and nature which nervous system it is that they act upon in giving rise to an emotional state. Now emotions originate (1) spontaneously, that is from some condition of the body or part of the body; (2) they are excited by thoughts through associations formed in the past; (3) they are excited by impressions received through the senses without the intervention of thought.

(1) A complete list of the instances in which emotions arise spontaneously, or from some condition of the body or part of the body, would be much too long to be recited here. I will first mention one or two physiological conditions, and then proceed to the pathological. The most prominent among these physiological conditions which give rise to emotional states is undoubtedly that set which underlies the development of sexual passion. The material part of these conditions is certainly an active and healthy state of the testes or ovaries; for if all the other conditions be present and this organ alone be either absent, or materially injured by disease, or immature, or atrophied, or functionally inert from age, or any other cause, this particular emotional state cannot be produced, while the absence or disease of no other organ will operate as a positive bar to its existence. The presence in the mind of the image of a person of the opposite sex, although to the unthinking it seems to be the chief factor in the production of this emotional state has in reality nothing at all to do with it in any fundamental sense, for the feeling may exist without any such image being present, and the feeling being fully aroused it may with many people be readily transferred from one mental image to another; whereas if the feeling were dependent upon the image this could not happen. It is in this way that we may account for those cases frequently seen in which a man upon a very short acquaintance marries a second woman upon the breaking off of an engagement with a first. Again, in the higher animals—in whom we must admit a psycological condition in sexual matters almost if not quite identical with our own—though some of them will not transfer their affections from one object to another, or will do so only with great difficulty and after a certain period of mourning, yet in others there seems little or no cohesion between the mental image and the emotional state, so that the sexual glands being active and the emotional condition in question being present, the individual upon whom the sexual favours may be bestowed is a matter apparently of entire indifference. These considerations seem to me conclusive against the theory that the emotional state is dependent upon the mental image, and the grounds given above seem also to establish the position that the state of the sexual secreting glands is the real determining cause of the emotion. This being the case we have next to ask with which nervous system are these glands most intimately connected? You know what the answer to this question is. The ovaries receive no nerves but from the sympathetic, and the testes, as we showed above, receive nerves from the cerebro-spinal system only because they are exposed and require to be endowed with sensibility for their protection. But if sympathetic nerves be the connecting link between the organ whose condition excites the emotion and the nerve centre in which that emotion arises, that nervous centre must be the sympathetic ganglia.

Hunger and thirst are probably true emotional states, and the arguments which follow would apply to them as well as to other emotional states having for their basis certain conditions of the stomach, but as they are not by any means universally looked upon as emotions I shall pass over them and proceed to discuss those alterations in the moral nature which are due to fullness and emptiness of the stomach.

Good and bad temper are beyond question states of the moral nature, and everybody knows how intimately these are associated with the conditions of fullness and emptiness of the stomach; of course I do not mean to say that all good and bad temper is due to this cause, but simply that this as a cause is capable of influencing the temper. Now the nerves of the stomach are the terminal branches of the right and left Pneumogastric, and a copious supply from the sympathetic—the nerves of the gastric plexus, an offset from the solar plexus, being sent to it as well as branches from the splenic plexus—the question is: do the pneumogastrics carry the impressions which excite feelings of good and bad temper, or do the sympathetic nerves carry these impressions? As far as I can answer this question I shall answer it further on when I come to consider emotional states which are excited by pathological conditions of the stomach.

The pathological conditions which give rise to emotional states are extremely numerous, and I wish particularly in this connection to draw your attention to the fact that it is invariably in lesions of organs well supplied by the sympathetic that these perversions of the emotional nature occur. As a rule in diseases of the brain, spinal cord, and muscular system, there is little or no derangement of the moral nature; on the other hand, in diseases of the stomach, heart, liver, kidneys, supra-renal glands, and of the testes, ovaries, and uterus, there is always some and often great disturbance of the emotions. You have all seen cases of dyspepsia in which constant low spirits and occasional attacks of terror rendered the patient's condition pitiable in the extreme. I, who have suffered in this way myself, can assure you that these cases which are often made light of deserve your hearty sympathy. In cancer of the stomach, ulceration of the stomach, and chronic gastritis, we see similar emotional disturbances. Now how do we know that these pathological conditions of the stomach produce terror and low spirits by impressions conveyed through sympathetic nerves to sympathetic ganglia, and not by impressions conveyed through the pneumogastrics to the brain? We infer it because all the accompanying morbid phenomena are certainly due to disturbance of the sympathetic. Thus a man is suffering from what we call nervous dyspepsia,—some day, we will suppose in the middle of the afternoon, without any warning or visible cause one of these attacks of terror comes on—the first thing the man feels is great but vague discomfort, then he notices that his heart is beating much too violently, then in a few minutes he falls into a condition of the most intense fear—he is not afraid of anything—he is just afraid; his mind is perfectly clear, he looks for a cause for his wretched condition but sees none—presently his terror is such that he trembles violently and utters low moans, his body is damp with perspiration. his mouth is perfectly dry, and at this stage there are no tears in his eyes though his suffering is intense. When the climax of the attack is reached and passed there is a copious flow of tears or else a mental condition in which the person weeps upon the least provocation. At this stage a large quantity of pale urine is passed; then the heart's action becomes again normal, and the attack passes off. Now what I wish you to notice is that all disturbance of function accompanying one of these attacks is disturbance of functions presided over by the sympathetic. We have seen above that the secretions are controlled by this nervous system and I have mentioned how the salivary, lachrymal, urinary, gastric, and cutaneous secretions are altered both by diminution and increase—the heart's action is almost certainly under control of the sympathetic, and it is greatly disturbed, the trembling, as more fully explained farther on, is probably the phenomenon produced when voluntary muscles are acted upon and thrown into action by the sympathetic nervous system. On the other hand we have no indication that the cerebro-spinal nervous system is in any way excited or disturbed—the mind is clear, the reasoning and perceptive faculties perfect, the control of the will over the voluntary muscles through the medium of the nervous system is in no way interfered with, and in fact so little is the centre of ideation involved that as I have stated no mental image is associated with the

emotion of terror, the man suffers simply from fear, not from fear of something. It seems then clear to me that the great sympathetic is the nervous system acted upon by the abnormal condition of the stomach, which in its turn reacts upon the economy, and that consequently the terror in question is one of its functions. The lungs receive a very small supply of sympathetic nerves and we know that long continued disease of their tissue ending in death will often scarcely give rise to low spirits, never to extreme depression or violent emotion of any kind. The heart receives a very large supply of sympathetic nerves, and its diseases as fatty degeneration of its substance, and calcareous degeneration of its arteries, are accompanied by very great depression of spirits and often by agonies of terror. The common forms of so-called heart disease, that is, imperfections of the cardiac valves, and contractions of the cardiac orifices, are not, in the sense in which I am now speaking, disease at all; for there is in these cases no tissue change, there is simply a change in mechanical conditions. The liver is moderately well supplied with sympathetic nerves and there is a moderate amount of disturbance of the moral nature in disease of its tissue as in cancer, and in impairment of its functions as in congestion; but as disease of the liver, either structural or functional, seldom or never occurs without either structural or functional disease of the stomach accompanying it, it is difficult to estimate the amount of the disturbance of the emotions caused by the hepatic conditions themselves. Emotional conditions excited by diseases of the kidneys are undoubtedly due in great part to the destructive changes going on in these organs, but they are also to a certain extent due to the uremic poisoning which necessarily accompanies them, and so the effect of the blood change and that of the organic change mask one another. But the case most clearly in favor of my argument is beyond question Adison's disease of the supra-renal glands. You know that the number and size of sympathetic nerves sent to these small bodies is extraordinarily great. You also know that they receive no cerebro-spinal nerves at all. Any of you who have seen cases of this disease or who have paid attention to the literature of the subject, are equally aware of the extraordinary effect produced by disease of these bodies upon the moral nature. Long before the patient is obliged by the extent of his illness to abandon his usual occupations he is greatly troubled with listlessness, languor and low spirits; as the disease advances these symptoms increase and attacks of terror and extreme low spirits are common. Now to return to our old argument—the morbid action is in the supra-renal gland, the nerves which convey the impressions which excite emotional disturbance are necessarily here sympathetic nerves—The nerve centre in which the emotional disturbance takes place is therefore the sympathetic ganglia—therefore the sympathetic ganglia are the nervous centre of emotional states.

(2) We ought next to consider the excitation of emotion by thoughts from association formed in the past of the species, or of the individual, but this subject is so large and in a condensed form would be so little satisfactory that I have reluctantly concluded to omit it altogether.

(3) The third and last class of emotional excitants which we are to consider is sense impressions acting upon the moral nature without the intervention of thought. The proper consideration of this part of the subject would alone occupy several such essays as I have time to read. I shall merely glance hastily at one instance of the class mentioned, namely: The excitation of emotions by sounds. All the infinite variety of sounds that strike upon the human ear may be divided according to their effect upon the human organism into two great classes, (a) those, namely, which, primarily excite ideas, and (b) those which primarily excite emotion. The noise of a carriage on the street, of fowl in the yard, of steamboats and trains passing, these, and thousands of other ordinary sounds, simply excite a mental recognition of what the sound proceeds from. But if you lie under pine trees on a summer's day and hear, without listening, the wind sigh and moan through the

boughs the emotional nature is moved irrespectively of any ideas that may be excited; so at the bedside of a sick child its moans and cries of pain affect us quite out of proportion to and irrespective of the value our mind may set upon them, for even if we know the child is not dangerously ill, nor suffering very much, still we cannot prevent, as is said in common language, its cries going to our heart,—and they do go to the heart, or at least to the centre of the emotional nature, direct. So a cry of pain or distress heard suddenly awakens a corresponding emotion in the hearer before any thought is aroused.

The types of these two classes of sound are, on the one hand spoken language, and on the other hand music. The former we know appeals directly to the intellect and does or does not arouse emotion, according as the thought awakened is or is not associated with an emotional state. The latter, we also know, appeals directly to the emotions and only awakens thought secondarily if it does so at all. Now does that class of sounds which appeals directly to the moral nature possess any quality which the other class does not possess which would make us think that it rather than the latter acts upon the sympathetic? It has one such quality, namely: rythm. All music is rythmic, and all language which appeals directly to the feelings, that is to say all poetry, is also rythmic. Now rythm is one of the leading qualities of the functions of the great sympathetic. All motions governed by it are rythmic, the heart's motion, and the motions of the intestinal canal, the contractions of the uterus in labor. I myself have no doubt that the duration of pregnancy, the determining cause of which has puzzled the world so much, as well as the periodic recurrence of ovulation are both due to the same cause, namely: the rythm, or periodicity of function of the great sympathetic system. Doubtless the chief advantage of regularity of time in taking meals is due to the fact that the gastric and salivary glands and other organs concerned in digestion, being governed by the sympathetic, their functions are best performed rythmically. Comparing the twenty-four hours to a bar of music the three meals and sleep are four notes which make up the bar and they require to be struck in true time and with the same intensity day by day to keep the music of the system true.

(B) The only thing that remains for me to do to complete this very short and imperfect sketch of a most important and much neglected subject, is to consider briefly the expression of the emotions to see if we can determine from which nervous system these phenomena proceed. As we cannot pretend to discuss the whole of this branch of the inquiry I shall limit the few remarks I have to make to the expression of (1) joy, (2) grief, (3) hate, (4) fear, (5) and to the expression of, or rather the effect of, long continued excessive passion of any kind.

(1) If joy is at all marked in degree it alters the heart's action—if excessive and sudden it arrests it momentarily, if more moderate in degree it makes it more frequent and stronger; excessive joy causes pallor for a short time and then slight flushing, moderate joy heightens the complexion. If joy is at all extreme it excites lachrymation in persons of mobile nervous organization. Sudden and great joy destroys the appetite, apparently by checking the salivary and gastric secretions—moderate joy stimulates the appetite doubtless by exciting the secretions which assist in digestion. Now all the above are disturbances of functions which are controlled by the sympathetic—but we know that joy also gives rise to movements of various kinds, for instance, laughter, clapping of the hands, stamping of the feet. The peculiarity of these movements is that they are all rythmical and we know what a tendency there is for the functions of the sympathetic to be performed rythmically. Now I do not mean to argue that it is the great sympathetic which excites the muscles to action in the production of these movements, but what I would suggest for your consideration is that the great sympathetic being the nervous system primarily excited it excites the cerebro-spinal system by means of its elaborate connection

with the latter, and the cerebro-spinal system, acting under the influence of the great sympathetic,—the character of action of the former is stamped by the influence of the latter.

(2) Grief is expressed by tears, pallor, loss of appetite, functions controlled by the sympathetic, by sobbing, wringing of hands, swaying to and fro of head and body, cerebro-spinal motions which are rythmical. Excessive grief kills. I have known of one death from this cause. The fatal result of grief is due to interference with nutrition or with the heart's action, the event in either case being brought about through the sympathetic.

(3) Hate or rage if intense is marked by pallor and partial arrest of the heart's action; if moderate by flushing; if considerable but still not intense the flushing is extreme, the face becomes purple, the veins of the neck and forehead swell. Monkeys as well as men are said to redden with passion. Some authors say the pupils always contract in rage, and this we can easily understand for if the muscular coat of the arteries is relaxed as it is shown to be by the distention of the vessels, then the radiating fibres of the iris which are also supplied by the sympathetic, would be equally in a semi-paralyzed state, and the circular fibres which are supplied by the third nerve would have less than usual to antagonize their ordinary tonicity and the pupil would contract. In great rage there is often trembling; this phenomenon I shall consider further under the head of fear. The above mentioned are the primary signs of rage and they are all brought about through the sympathetic. Other signs of rage as snarling, setting the teeth, clenching the fists, etc., are manifestly secondary; they result from intention in ourselves or our ancestors of doing something in consequence of rage and are not the direct effect of the passion itself.

(4) The disturbances of function which accompany fear are frequent and feeble action of the heart, pallor, dilitation of the pupils. (I wish you particularly to remark that whereas in rage there is flushing of the face and contraction of the pupils, as I have shown above, in fear there is pallor of the face and dilitation of the pupils—the muscular coats of the arteries and the radiating fibres of the iris both being supplied by the sympathetic, and both being stimulated to contract under the influence of terror, and both being relaxed in rage.) In fear there is also suppression of the salivary and gastric secretions—extreme dryness of the mouth, and absolute abeyance of the appetite—there is frequently increase, sometimes very marked of the urinary and intestinal secretions. Trembling is one of the most characteristic signs of fear. This is a movement of the voluntary muscles, but it is not a voluntary movement, the will having no control whatever over it. Trembling occurs in other emotional conditions besides fear, as in joy and rage—the shaking of ague though not associated with any emotional state is, I have no doubt, closely connected with emotional trembling. No author with whose works I am acquainted gives any explanation of this phenomenon. Were I to attempt one myself it would be that trembling is the peculiar movement of the voluntary muscular tissue when thrown into action not by its own proper nervous system, the cerebro-spinal, but by the sympathetic; and I would argue that this was the correct view of the case—first, because it is certain that trembling occurs when the sympathetic is highly excited; secondly, because the cerebro-spinal system cannot as far as we know cause such a movement, and cannot control it when caused; and thirdly, because of its peculiar rythmical character which allies it to other movements originating in the sympathetic. If I had time, which I have not at present, I could support these arguments by showing, I think conclusively, that ague, of which a peculiar trembling is one of the most prominent symptoms, is certainly a functional disorder of the great sympathetic; and it is upon this fact that its peculiar periodicity depends. With regard to the sweating of great fear I have no explanation to offer, I will simply remark that when by division of sympathetic trunks a part of the surface of the body is deprived of its connection with the sympathetic centres that part of the surface is bathed in sweat. I have quoted very few

experiments upon the sympathetic in this essay, though I might have quoted almost any number of them, for the reason that I put very little confidence in the deductions drawn from them. To divide large sympathetic trunks, or to remove large sympathetic ganglia must cause a disturbance of the system at large which would necessarily mask the peculiar effects flowing from the lesion of the nerves operated on, and any one who has paid attention to the literature of this subject cannot have failed to notice how contradictory are the positions supposed to be established by these means. Without denying that experiment may in the future throw light upon this branch of physiology, I think it is safe to say that it has thrown very little light upon it yet.

(5) If there is one fact in relation to the function of the great sympathetic better established than any other it is that this nervous system exercises a most decided control over the process of nutrition. Now I beg of you to consider for a moment what a curious relationship exists between this processs of nutrition and the habitual state of the moral nature. The best observer of man that ever lived on this planet makes Cæsar say to Antony:—

"Let me have men about me that are fat;
* * * *
Yond' Cassius hath a lean and hungry look;
He thinks too much; such men are dangerous.
* * *
Would he were fatter* * *
* * he loves no plays,
* * he hears no music,
Seldom he smiles; and smiles in such a sort
As if he mock'd himself, and scorned his spirit
That could be moved to smile at anything.
Such men as he be never at heart's ease,
* * * *
And therefore are they very dangerous."

Shakespeare says, what we all know is the rule that men in whom dwell a preponderance of evil passions, such as hate, envy, and jealousy, are ill-nourished. The converse of this is as notorious, so that fat and jolly go together as naturally as do any two terms in the language. Not only does this general law hold, though liable to many exceptions from the operations of other laws interfering with it, but we find it equally true that any long-continued inordinate passion, be it sexual love, hate, envy, or grief, is capable of influencing nutrition in a marked manner. Long-continued thought does not produce any such effect, if it seems to do so sometimes it is because the student deprives himself of proper air, exercise, or sleep, in his ardent devotion to knowledge. Newton was as fat when he finished the Principia as when he began it. The writing of the Novum Organum did not reduce Bacon's weight a pound. Shakespeare, in whose splendid brain fermented all the ideas of his time, and it was a time perhaps, of more ideas than the present, much as we pride ourselves in this respect, was a well nourished man. The moral natures of Newton and Bacon were calm and serene, Shakespeare's heart glowed with a genuine love of humanity. If the moral nature be equally with the intellectual a function of some part of the cerebro-spinal nervous system, why are the undoubted functions of the great sympathetic so intimately connected with the one and so entirely unconnected with the other?

I must now, gentlemen, close this imperfect sketch of a most important, and, to me at least, most interesting subject. The conclusions at which I have arrived in my own mind from the arguments mentioned here, and from many others that I have not had time to-day to bring forward, are as follows: 1. The great sympathetic is a nerve of motion to unstriped muscle. 2. It is not endowed with sensation. 3. It exercises a controlling influence over the functions of the secreting glands. 4. It governs nutrition. 5. It is the nervous centre of the moral nature.

One word more. I wish to tell you my whole mind on this subject, and it

is this: That whereas the cerebro-spinal nervous system is an enormous and complex sensory-motor apparatus with an immense ganglion, the cerebrum, whose function is ideation, superimposed upon the sensory tract; and another, the cerebellum, whose function is the co-ordination of motion, superimposed upon the motor tract—so the great sympathetic is also a sensory-motor system with out any superimposed ganglia, and its sensory and motor functions do not differ from those of the cerebro-spinal system more than its cells and fibres differ from those of this latter system—its efferent or motor function, namely, being expended upon unstriped muscle; and its afferent or sensory function, being that peculiar kind of sensation which we call the moral nature. Upon this view of the case the only efferent function of the sympathetic is stimulation of unstriped muscle, and we should have to view its influence upon secretion and nutrition as due to its power of contracting or allowing to dilate the coats of the arteries; and this is in all probability the correct view of the matter. Looked at in this way the bulk of each system seems to correspond with the scope of its functions, for the sensory-motor functions of the cerebro-spinal system, including ideation and co-ordination of motion, would be as much in excess of the functions of the great sympathetic in amount and complexity, as would the ganglia of the former be in excess of those of the latter in complexity of structure and bulk.